



International **WOCE** Newsletter



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IN THIS ISSUE

WOCE Global
Data CD V3

Status of Data
Assembly Centres

WOCE Atlases

WOCE
Bibliography

Ocean Transports
Workshop

Air-Sea Fluxes

Final WOCE
Conference

News from the WOCE IPO

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The WOCE Newsletter is back again

After a (too long) interruption following Roberta Boscolo's move to Vigo, I am very pleased that the WOCE Newsletter is back in business. Dr Mike Sparrow has joined the WOCE IPO to be the manager for the WOCE Atlas project (see page 6) but he will also be the WOCE Newsletter editor. Mike did his PhD at the University of East Anglia (on the circulation of the South Indian Ocean) and then worked in Madrid at AINCO Interocean on the EU CANIGO and Eurofloat projects analysing the structure of the Azores Current and the circulation of Mediterranean water in the Madeira basin. We welcome him to the WOCE IPO.



The contents of this issue (Number 41) will serve to bring our readers up to date with what is going on and we plan that the next issue will focus again on WOCE science. It will have input based on the papers and posters presented at the WOCE/JGOFS Ocean Transports Workshop in June 2001 (See page 10), though contributions on other subjects will also be welcome. We're glad to have a Newsletter again. We hope you are pleased too. Below are reports of two key meetings.

The WCRP Joint Scientific Committee

This met at NCAR, Boulder, USA March 19-23. WOCE was represented by Dr Bill Large the SSG Co-Chairman and me. The presentation focussed mainly on the WOCE data system, its successes and the lessons that might be learned by other WCRP projects. WOCE has had remarkable success in ensuring that the data it needs

About WOCE

The World Ocean Circulation Experiment (WOCE) is a component of the World Climate Research Programme (WCRP), which was established by WMO and ICSU, and is carried out in association with IOC and SCOR.

WOCE is an unprecedented effort by scientists from more than 30 nations to study the large-scale circulation of the ocean. In addition to global observations furnished by satellites, conventional in-situ physical and chemical observations have been made in order to obtain a basic description of the physical properties and circulation of the global ocean during a limited period.

The field phase of the project lasted from 1990–1997 and is now being followed by Analysis, Interpretation, Modelling and Synthesis activities. This, the AIMS phase of WOCE, will continue to the year 2002.

The information gathered during WOCE will provide the data necessary to make major improvements in the accuracy of numerical models of ocean circulation. As these models improve, they will enhance coupled models of the ocean/atmosphere circulation to better simulate – and perhaps ultimately predict – how the ocean and the atmosphere together cause global climate change over long periods.

WOCE is supporting regional experiments, the knowledge from which should improve circulation models, and it is exploring design criteria for long-term ocean observing system.

The scientific planning and development of WOCE is under the guidance of the Scientific Steering Group for WOCE, assisted by the WOCE International Project Office (WOCE IPO):

- W. John Gould, *Director*
- Peter M. Saunders, *Staff Scientist*
- N. Penny Holliday, *Project Scientist*
- Mike Sparrow, *Project Scientist*
- Jean C. Haynes, *Administrative Assistant*

For more information please visit:

<http://www.woce.org>

are safeguarded, quality controlled and made available to researchers. Much of the system of Data Assembly and Special Analysis Centres (DACs and SACs) was established specifically for WOCE and was based on the active involvement of scientists in the management of the data. This success is seen in the high proportion of measurements made that are expected to be included in the third and final version of the WOCE CD-ROMs that will be issued next year. (See note by Jim Crease on page 5). WOCE spent only a small fraction (~2%) of its research budget on data management and with hindsight this should perhaps have been higher. For instance, satellite projects typically spend a much higher proportion of their project budgets on data management and distribution.

The presentation to the JSC also focussed on the various steps that would mark the project's progress in the final stages. These included the publication of the book "Ocean Circulation and Climate – Observing and Modelling the Global Ocean" that originated from the 1998 conference. The first printed copy of the book arrived at the JSC meeting and everyone was pleased with its quality and content. The joint WOCE/JGOFS ocean transports workshop was seen as an important collaborative venture between WOCE and JGOFS and indeed the need for closer collaboration between WCRP and IGBP was a theme running through the JSC meeting and included a discussion of WCRP's likely involvement in the IGBP's Surface Ocean – Lower Atmosphere (SOLAS) project (<http://www.ifm.uni-kiel.de/ch/solas/main.html>) and the development of a WCRP-IGBP-IHDP Joint Carbon Project.

The format and objectives for the final WOCE Conference were discussed with the JSC (see article page 14). The JSC suggested that there might be benefit in holding joint WOCE/JGOFS sessions at major oceanographic/climate meetings early in 2003.

WOCE will formally end as part of WCRP at the end of 2002 and will make its final presentation to the JSC meeting in spring 2003.

Presentation to the IOC Assembly

Every two years the Intergovernmental Oceanographic Commission (IOC) holds its assembly in Paris. At the past 3 assemblies I have



been invited to make a presentation on WOCE in the session on Oceans and Climate (IOC co-sponsors the WCRP). This year I focussed on the advances that have been made since WOCE was conceived in the early 1980s. There are many things that we now take for granted that that were still only a hope or dream at the start of WOCE. The following is a selective list :-

- Continuous navigation to ~3m – even in 1990 GPS was intermittent and deliberately degraded
- Ships heading from GPS to 0.1° instead of gyro good to 2-3°
- Better ship-board (and now lowered) ADCP due to better navigation
- Satellite altimetry to ~2cm

- Global surface wind fields from scatterometers
- Ocean tracer measurements using 10 litre samples instead of 200 litre needed at start of WOCE
- Profiling floats – only prototypes in 1990 - now operational and the basis of the global Argo programme
- Global ocean models to ~1/10° resolution

I stressed to the delegates how the WOCE global survey in the 1990s provides a baseline against which change may be assessed and noted how the data would be distributed both on-line and via the CD-ROMs. Finally I presented to Dr Patricio Bernal (Executive Secretary, IOC) a copy of the WOCE book and of the CD-ROMs V2. (see photo on page 2). The delegates expressed their appreciation of the remarkable progress made by WOCE.

Countdown to the Final Issue of the WOCE Global Data

N. Penny Holliday, WOCE IPO, SOC, Southampton, UK. nph@soc.soton.ac.uk

WOCE is the most significant global experiment carried out by oceanographers since the International Geophysical Year (1957). It has provided the reference oceanographic data for understanding climate change, large-scale ocean circulation and for future programmes such as CLIVAR. These data will possibly be the greatest legacy of the WOCE experiment.

The compilation of the ultimate WOCE data product, the complete WOCE data set online and on disk, is now underway and on schedule for release in late 2002. The team of scientists and data centre managers that make up the WOCE Data Products Committee (DPC) have designed the specifications for Version 3.0 of WOCE Global Data and are currently working hard on implementing them.

The greatest achievement of Version 3.0 issue will be that it contains the complete WOCE data set, with full quality control and documentation. Figure 1 shows the percentage of data that are currently at the DACs, and that are expected to be received and processed by the time Version 3.0 is issued. Remarkably some DACs have already been able to acquire and present 100% of the data collected (see Crease article on the Current Meter DAC, page 5). Overall, Version 3.0 is expected to contain over 90% of the data actually collected during the 9 year WOCE field programme; a much greater success rate than previous international programmes. The remaining 5-10% is mostly accounted for by data that remain unprocessed due to resource limitations or through known quality problems, rather than data originators not submitting data. This achievement has

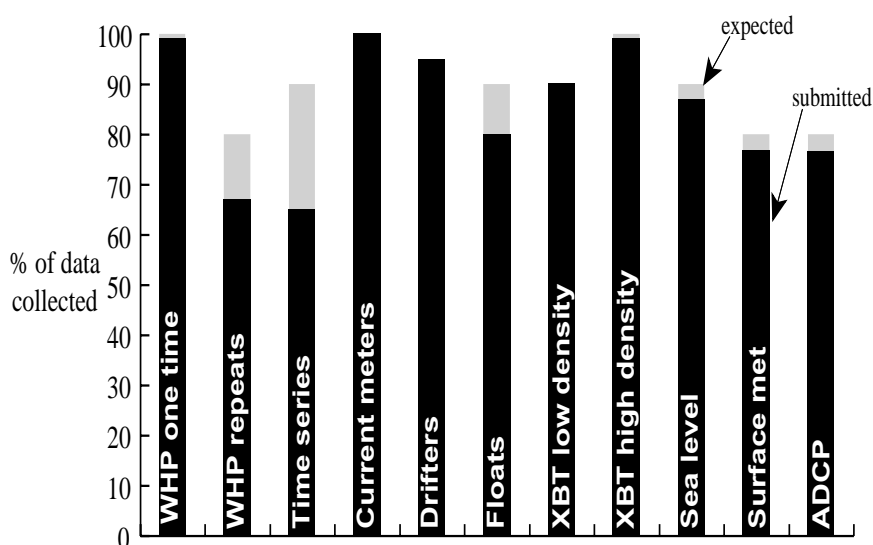


Figure 1. WOCE data submission progress (July 2001). The columns represent the percentage of all data collected during the field programme (1990-1998); black being data at the DACs, grey being data expected to arrive before the issue of Version 3.0. The DACs are on target to acquire, quality control and document over 90% of all data collected during the WOCE field

taken a great deal of hard work by the DACs and by the data originators, and is a reflection of the excellent co-operation between principal investigators and the data system developed to support them.

In addition, the Version 3.0 issue will provide enhanced search and retrieval capabilities over Versions 1 and 2. All data will be in the netCDF format to provide greater consistency of access to the 13 data streams. Many common applications (such as ncbrowse, Ferret, GMT, GrADS, IDL and Matlab) will automatically recognise and read any of these data streams ready for analysis and comparison. The DPC is always mindful of potential users who may prefer to work with ASCII files, so Version 3.0 will also contain full instructions, source programs and scripts on how to extract ASCII files from the netCDF format. Tools are currently being developed to create searchable inventories of the WOCE data sets, and to develop a basic search and retrieval facility to operate across the different data types. In both cases, the DPC is modifying existing technology to meet the WOCE requirements for ease of analysis and synthesis. The Data Information Unit at the University of Delaware is leading the development work (www.wocediou.org).

As for earlier versions of the WOCE Global Data, the product will be available on disk as well as being on most of the DAC websites upon completion. Looking beyond 2002, the WOCE Global Data will continue to be obtainable from US-NODC, the official archive for the programme. However, the DPC also intends to make the WOCE Global Data accessible online with enhanced search and retrieval facilities. As some of the WOCE DACs close down in 2001 and 2002, the DPC is looking at ways in which to keep the data available on existing and future ocean and climate data

servers, one example being the US Virtual Ocean Data Hub. The decision to present the WOCE data in netCDF has the added benefit of enabling data to be accessed immediately by such systems, so the DACs do not have to direct new resources to put up their data on such servers.

Many of the WOCE DACs will close for business in 2001 and 2002, and consequently there is a compelling motivation for data holders to send their data to the appropriate DACs. Others will continue operating under research programmes such as CLIVAR, or operational activities such as GOOS and national initiatives. The status of the DACs is summarised in Table 1. The early closure of two centres in 2001, the Current Meter and Subsurface Float DACs, has implications for the production of Version 3.0; both DACs will produce a disk of their complete data and documentation holdings before they close, but the disk will not be issued prior to the publication of Version 3.0. In this way, data originators who still wish to retain proprietary rights can be sure their submitted data will not be made public until late 2002. All the current meter data have now been submitted, but any float data not submitted by the middle of 2001 will not be included in the final WOCE Global Data issue. Many of the DACs which will continue into 2002 are finalising their data holdings in late 2001, to allow time for processing, quality control, documentation conversion to netCDF format, and final integration across all WOCE DACs. If you have outstanding data and wish it to be included in the final WOCE Global Data Version 3.0 then you must send it in now, with permission to release by mid to late 2002.

The WOCE Global Data Version 3.0 will be issued in time for the WOCE Conference in San Antonio, Texas, 18-22 November 2002.

DAC	Location	Expected Closing Date
Current Meter	Oregon State Univ.	Aug 01
Floats	WHOI	Sept 01
WHP Office	SIO	Dec 01*
Sea Level	Univ. Hawaii, BODC	Dec 02*
Surface Met	Florida State Univ.	Feb 02*
Surface Drifters	AOML, MEDS	Ongoing **
XBTs	MEDS, US-NODC, IFREMER, JAFOOS, AOML, SIO	Ongoing **
ADCP	Univ. Hawaii/US-NODC, JODC	Ongoing **

Table 1. WOCE Data Assembly Centre Financial Status (as reported to the DPC meeting in March 2001).

* Indicates intent to continue beyond the end of expected closing date if funding is secured
 ** expects to continue through end of 2002 and possibly beyond.

The Current Meter Data Assembly Centre

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The Current Meter Data Assembly Centre (DAC) (Dale Pillsbury, Joseph Bottero and Mindy Berger at Oregon State University) expects to close down in August 2001. One of the earlier DACs to be established and funded by the US/NSF, it has achieved the enviable record of assembling and quality checking 100% of the records from current meters identified in WOCE, either as part of the programme or from programmes whose results contribute to WOCE. This effort, of course was also totally dependent on the great co-operation of all the PI's in working with the DAC to make their data readily available to us all. The final dataset will be available on a CD at the time of the WOCE conference in November 2002.

In the late 80s, the Scientific Steering Group approved the idea of DACs each catering for different elements of the field programme and each led by scientists involved in, and knowledgeable with, the methodology for which the DAC was responsible. Their job was to assemble, quality control (qc), and make available to other WOCE PIs, the datasets defined in the WOCE field programme. We expected much of the *scientific* qc would, as in the past, be done by the PIs. In addition, useful summary products would be developed. This approach is providing a useful model for future programmes.

The current meter DAC has indeed developed precisely along these guidelines and has, I believe, worked well with the PIs and the wider oceanographic community. I now want to comment on aspects of their work.

The local eddy and mean statistics of the velocity field are often of immediate interest so these are routinely computed by the DAC. Indeed, PIs have frequently been ready to pass their data to the DAC at an early stage after recovery with the proviso that the statistics could be made public prior to the release of the full dataset. This has worked well to the extent that in one case the statistics are available up to the end of 2000. We are unaware of any case, among the several thousand downloads, where the data has been accidentally released prior to the PIs agreement.

The generation of edited datasets to the original in situations in which, for example, there was felt by the DAC to be excessive noise was not always so enthusiastically received by all PIs. Interaction with the PIs usually resulted in the publication of both original and edited sets together with an account of the differences.

Briefly, individual data sets of a year or more duration each are available from 38 arrays, 445 deployments, and 1993 records (see Figure 1). In addition, there are approximately the same number

of records from other non-WOCE deployments which either the Oregon group had been directly involved with or had acquired from colleagues. These non-WOCE datasets will on present plans cease to be available in the very near future.

For each array there is a chart showing the topography of the region around the moorings (see Figure 2 for an example) and in some cases a vertical section showing the location of the individual current meters in the water column. The data is available on-line in a zipped ASCII format and on the WOCE CD in NetCDF, the format of preference of the DPC for the final WOCE CDs. As mentioned already, the single record statistics for every record (means and co-variances) are also given.

Documentation includes:

- * A brief description of the particular experiment associated with the array
- * A list of publications related to the array
- * Comments on the data, particularly when potential problems have been noted by the DAC.

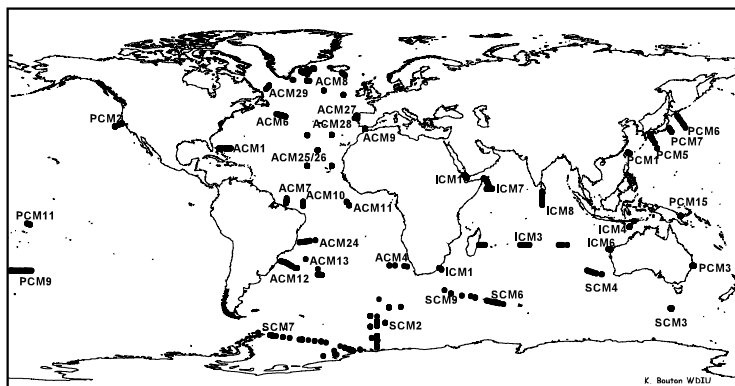


Figure 1.
WOCE current
meter data
available as of
June 30, 2001

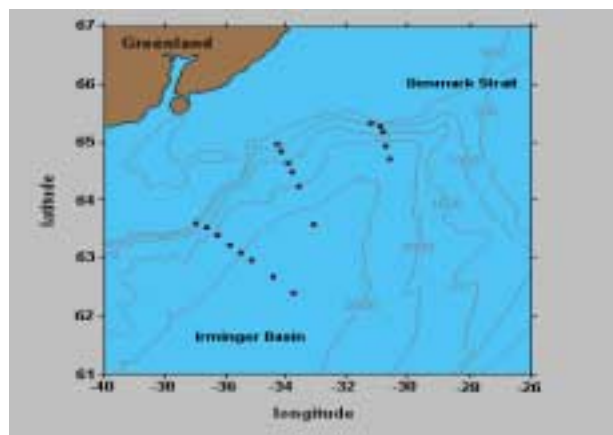


Figure 2. Denmark Strait Overflow (ACM8). Mooring locations are shown as dark squares.

The WOCE Atlas Series

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The “classic” legacy of oceanographic expeditions has been the publication of atlases of the data. For many people these atlases define what the ocean looks like and how it behaves. Oceanographic programmes such as the German Meteor Expedition during the 1920s, the International Geophysical Year (1957-1958), the International Indian Ocean Expedition during the 1960s, and the GEOSECS Expeditions during the 1970s have given us a series of atlases that provide very elegant “snapshots” of the ocean at the time. These volumes have proved of great value to generations of oceanographers, being easy to access, study and reference.

Now we have WOCE, the largest oceanographic expedition ever mounted. In comparison to earlier efforts, WOCE has a broader scope, greatly increased horizontal and vertical sampling density, improved accuracy and precision and a greater abundance of properties sampled. It is unlikely that such a set of data will be bettered or even repeated soon. Both the international WOCE SSG and the U.S. SSC agreed that it would therefore be fitting for WOCE to leave a similar legacy, which will likely become the benchmark volumes in oceanography and serve as world reference standards for years to come.

The plan is to produce a series of four atlases, concentrating respectively on the hydrography of the Pacific, Indian, Atlantic and Southern Oceans. The Southern Ocean is given a separate volume because of the importance of the circumpolar flow on the transport of heat, freshwater and dissolved components. The volumes will each have three components: Full-depth sections, horizontal maps of

properties on density surfaces or within core layers, and property-property plots. The vertical sections will feature temperature, salinity, neutral density, oxygen, nitrate, phosphate, silicate, CFC-11, $\delta^3\text{He}$, tritium, ^{14}C , total alkalinity and total carbon dioxide, against depth along each of the WHP one-time lines (Fig.1). In keeping with previous publications, the vertical exaggeration of the plates will vary, with the upper 500m (in the Southern Ocean) or 1000m (elsewhere) being shown at a higher vertical exaggeration than the total water column, reflecting the larger parameter gradients near the surface.

The horizontal maps will combine the WOCE data with the best available historic data for each ocean and concentrate on about eight layers. Choice of which historic stations to include as well as which levels to show rests with the PI responsible for each atlas volume. The same is true at present for the property-property plots; with 12 variables (ignoring neutral density) it is impossible to show all 66 possible combinations for every line. However, it is expected that a standard set of property-property plots will evolve with only a few special exceptions.

To date, three proposals are being supported to format the WOCE hydrographic data and prepare the plates for printing. In the U.S., Lynne Talley is preparing the Pacific and Indian Ocean data, while Alejandro Orsi is preparing the data from the Southern Ocean, both with funding from the National Science Foundation (NSF). In Germany, Peter Koltermann is funded by the BMBF (Bundesministerium für Bildung und Forschung) to prepare the Atlantic Ocean data.

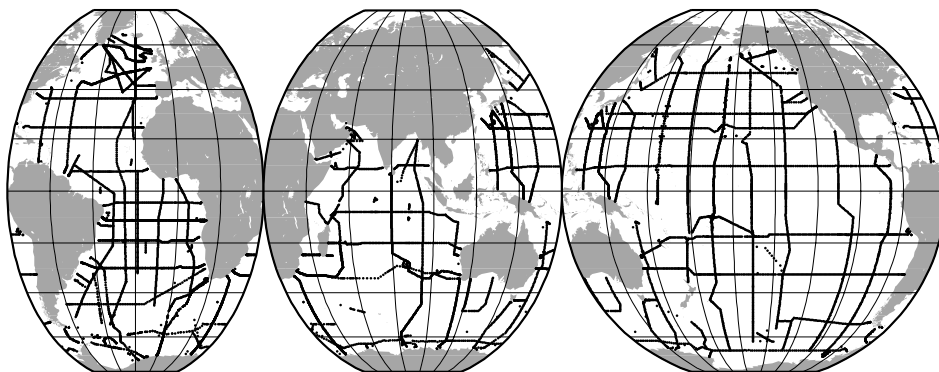


Figure1. WHP one-time lines.

It was always realised that printing would be a major problem, given that the atlas requires four-colour printing on almost every page. Thankfully, after several attempts to interest philanthropic foundations came to naught, John Gould caught the interest of BP-Amoco. The company has agreed to cover production costs.

The oversight of the project is vested in an international atlas committee, chaired by Peter Saunders at the IPO. The funded atlas groups met in Southampton in March 2001 to settle many of the annoying small details which, if left undefined, would have major effects on the final products. For instance, much entertainment was caused when it was discovered that everybody was working from what they believed to be identical colour swatches (all of which turned out to be different when the PIs actually met). Considerable help was given by Technart - the printers who produce the WOCE Newsletter - in adopting common

pallettes and in resolving technical questions about paper quality, weight and opacity and the printing process.

In addition to the hard-copy versions of the atlases, it is envisioned that each group will also prepare an electronic version of the atlas. These will be available through the web and contain additional parameters, e.g., sections and maps of sigma-theta, sigma-4, CFC-12, nitrite, and $\delta^{13}\text{C}$, where enough data exist. Additionally, they could include extra levels and property-property plots, as well as the data used in creating the plates. It is hoped that a CD-ROM version of the electronic atlas can be made available with the hard-copy version.

We are still at the start of the production process but now that Mike Sparrow is in post hope to have the first (Pacific Ocean) volume printed early in 2002, with at least one other volume also being ready before the final WOCE Conference in San Antonio in November 2002.

IMS Mini-Meeting Statistical Approaches to the Ocean Circulation Inverse Problem November 13-14, 2001 Florida State University, Tallahassee, Florida

This mini-meeting is designed to foster interaction between statisticians and oceanographers with a common interest in inverse problem methods.

Oceanography has evolved very quickly over the past decade with the increasing realisation of the ocean's importance to climate around the globe, the implementation of large field experiments such as WOCE and with the development of new technologies to measure temperature, water movement, and other quantities in the ocean from space with satellites.

A major effort is being made to integrate diverse observations and analyse larger datasets. These efforts are challenging because of the basic complexity of the ocean and climate system. Variability exists at the longest and shortest space and time scales, and presently little is known about the spatial and temporal coherence of ocean circulation.

Furthermore, despite the observational efforts, datasets are typically sparse, and methods of analysis typically must incorporate dynamical information about the circulation in order to proceed. Studies of the basic statistical variability, mapping, estimation, and more sophisticated forward and inverse modelling techniques are being developed and used in the oceanography community to determine circulation. On the other hand, a large variety of inferential methods for the study of indirect or sparsely measured phenomena, including Bayesian techniques and nonparametric smoothing for spatio-temporal data, have been developed by statisticians in recent years. So the time is ripe for a fruitful interaction between the oceanographic and statistics communities to discuss this topic.

The meeting will have an informal workshop flavour, open to anyone interested in attending. There will be no registration fee. A poster session will be organised for all presentations other than invited talks.

Invited Speakers: Carl Wunsch (MIT), Philip Stark (Berkeley), Keith Haines (Edinburgh), Grace Wahba (Madison), Detlef Stammer (Scripps), Peter McIntosh (CSIRO), Doug Nychka (NCAR), Chris Wikle (Missouri).

Persons interested in attending or in presenting a poster should notify Pam McGhee, Department of Statistics, Florida State University, Tallahassee, FL 32306-4330; e-mail: mcghee@stat.fsu.edu. Further information is available at <http://stat.fsu.edu/ocean/>.

The WOCE Website and Bibliography

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The Website

The WOCE Website is a showcase for the project and two improvements were made this past spring: The domain name of the site was (belatedly) changed to www.woce.org (although the old address still works) and the pages were rearranged to make them friendly to first time users. These efforts were spearheaded by Katherine Bouton but were a collective IPO effort.

It is unnecessary to elaborate on the new structure since this is evident by visiting the site, but I will comment on two features here, one new, one old. The most significant

addition has been the introduction of a section devoted to WOCE science achievements. These were derived from material in the WOCE Book, Ocean Circulation and Climate: Observing and Modelling the Global Ocean (Academic Press) which I trust most readers will have seen or be aware of. From the chapters of the book about 10 topics were selected in which significant advances to our knowledge of the ocean circulation had been made, and these subjects are briefly described and colourfully illustrated on-line. If you have recommendations for additional topics please write and let me know.

Linked with the science achievements are the sites for WOCE data. Many of you will possess CD-ROMs of WOCE data but these collections are constantly being added to as both tardy and late-acquired data come in. Next year the final version of the CD-ROMs will be issued - see the article/note by Penny Holliday (page 3) in this issue - but much of the data we hope will remain on-line. The data site (DAC) managers have done a terrific job over the past decade and deserve all our plaudits.

Incidentally, amongst the data sites you will find a page devoted to transport estimates mostly within western boundary currents derived from WOCE arrays of moored current meters, which has been an initiative I am pleased to have pursued. References to both published and unpublished material will be found there.

The Bibliography

The WOCE Bibliography is another aspect of the project achievements. At present the bibliography contains about 5600 entries of which about 1350 are refereed publications attributable to the project. About 2800 other refereed articles have also been included. These are from other projects or individual/group

Figure 1. WOCE Bibliography Content

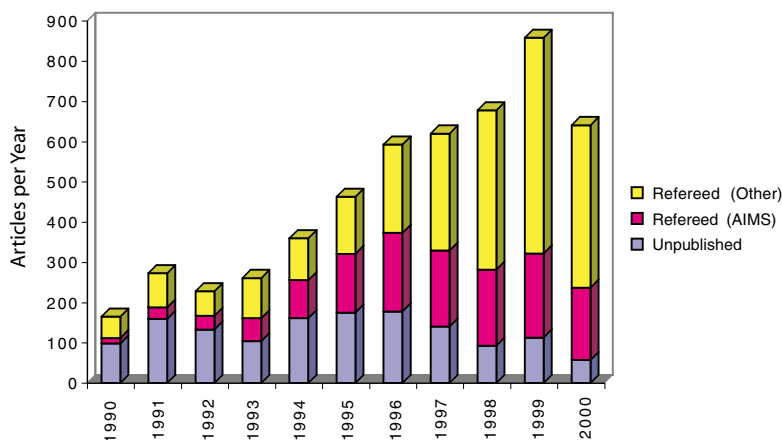
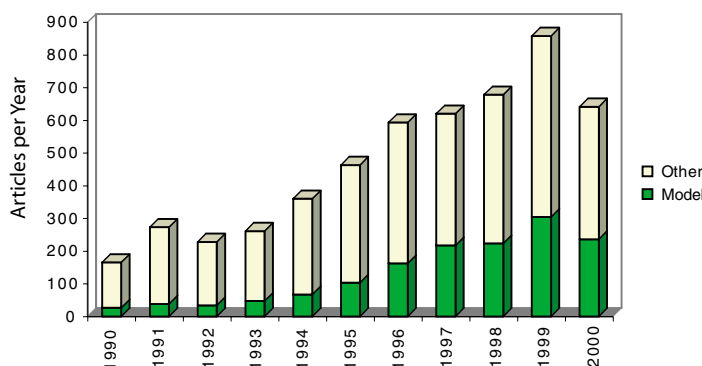


Figure 2. WOCE Bibliography Content



research programmes which were carried out in the WOCE time frame and, like WOCE, were also concerned with aspects of the large scale circulation of the ocean. These references were included to add to the utility of the bibliography for both WOCE and non-WOCE researchers. There are also about 1450 articles from (technically) unpublished or grey literature describing, for example, WOCE meetings, field and cruise reports and publicity material, which dominated the early years of the project but whose number has now dwindled to a trickle. The evolution of these three classes of publication annually can be seen in Fig 1.

How do we attribute refereed publications to WOCE? In a number of ways. If the authors acknowledge WOCE as the source of support. If the WOCE national committees, almost all entirely now defunct, included them in lists which they periodically produced. (Such lists were provided by Canada, France, Germany, Japan, UK, USA - if my memory serves me right). If the authors employed WOCE data. And finally where authors were key WOCE players. Of course there is some subjectivity in this list and especially

where Ocean General Circulation Model (OGCM) development and results were reported. As can be seen from Fig. 2 publications concerned with ocean models are a significant fraction of the WOCE bibliography. If you wish to search for WOCE attributed papers search on the keyword AIMS - Analysis, Interpretation, Modelling and Synthesis.

Mention should also be made here of the special collections of WOCE publications, which have often followed on a WOCE workshop but are not confined to this route. See the accompanying table.

The bibliography is not complete of course, as the table illustrates, and additions will continue to be made into the future. This Spring the WOCE book with its nearly 2000 references furnished nearly 300 new references to the WOCE collection. Further information about the bibliography and how regional and topical searches may be made can be found in a paper by Saunders, Bouton and Simpson in the International WOCE newsletter No 33 printed in December 1998.

WOCE collected publications		
Topic	Number	When/Where Published
TOPEX-POSEIDON	48	Dec 94 / JGR 99(C12) 24369-25062
TOPEX-POSEIDON	32	Dec 95 / JGR 100(C12) 24893-25382
WOCE Indian Ocean Expedition	11	Nov 97 / GRL 24(12) 2539-2580
WOCE Indian Ocean Expedition	9	2773-2809
WOCE Pacific Workshop (Aug 96)	12	Jun 98 / JGR 103(C6) 12897-13092
WOCE S. Atlantic Workshop (Jun 97)	22	Sep 99 / JGR 104(C9) 20859-21226
WOCE Southern Ocean Workshop (Jul 97)	12	Feb 01 / JGR 106(C2)
WOCE Conference (May 98)	32	Mar 01 / Book Academic Press 750 pp Ocean Circulation and Climate: Observing and Modelling the Global Ocean.
WOCE Indian Ocean Workshop (Sep 98)	In press or pending	01 / DSR II
WOCE N. Atlantic Workshop (Jun 97)	In press or pending	01 / JPO
WOCE/CLIVAR Variability Workshop (Oct 00)	In press or pending	02 / JGR

WOCE/JGOFS Workshop on the Ocean Property Transports Southampton Oceanography Centre June 25-29 2001

W. John Gould, SOC, UK. John.gould@soc.soton.ac.uk; Simon Josey, SOC, Southampton, UK; Kevin Speer, Florida State University, Tallahassee, USA, and Carl Wunsch, MIT, Cambridge, MA, USA

A workshop on global issues and particularly on the estimation of ocean transports of heat and freshwater was planned to be the last in the series of WOCE AIMS-phase regional and subject based workshops. Carl Wunsch chaired the scientific steering committee (who were Harry Bryden, Simon Josey, Jochem Marotzke, Herlé Mercier, Kevin Speer, Peter Saunders, Masao Fukasawa, Susan Wijffels and Jürgen Willebrand) and the UK Southampton Oceanography Centre agreed to host the workshop.

In parallel, the IGBP's Joint Global Ocean Flux Study (JGOFS) were planning a workshop to review their progress on assessing the ocean's ability to store and transport carbon. The physical measurements and modelling activities of WOCE clearly underpinned the carbon deliberations and in mid-2000 it was agreed that the two workshops would be held together.

The Workshop objectives were to review progress towards the estimation of the oceanic transports of heat, freshwater, carbon and other properties and their divergences and exchanges with the atmosphere. These estimates included those based on individual and groups of transocean sections, basin-scale and global inverse calculations, ocean state estimations and ocean only and coupled ocean atmosphere models. The early part of the week had a WOCE emphasis with JGOFS occupying the second half. There were 45 poster submissions from the total attendance of 94 scientists from Australia, Bermuda, Canada, France, Germany, Italy, Japan, Norway, Russia, Spain, UK and USA. The attendees included both senior and junior scientists. The plenary sessions (with input from assigned commentators) stimulated some lively discussions.

The Workshop only briefly touched on the many new results, and focussed almost completely on the remaining problems and requirements on future work. The following are some initial conclusions that will be refined as the meeting report is compiled:

1) The 1990-98 WOCE/JGOFS global survey succeeded in providing the necessary baseline for global mean oceanic transports against which future changes can be measured. The main issue now is to better understand the remaining uncertainties.

2) Mean transports over the WOCE period are determined to varying degrees of uncertainty, depending on the model configuration, *a priori* variances, and extra constraints used in the calculation. Nevertheless, significantly determined

values are emerging from WOCE analyses. However, seasonal and near-seasonal high-frequency components and interannual variability of oceanic transports are still poorly determined and represent a significant uncertainty in the determination of mean values.

3) The accuracy of direct estimates of the air-sea exchanges of heat, freshwater and carbon is limited by a number of factors. These include the sparseness of measurements at high latitudes, errors in the flux parameterisations (e. g. the neglect of aerosol loading is likely to lead to a bias in the estimated shortwave flux) and residual biases in the meteorological variables reported from ships. Progress is being made towards reducing regional biases in the heat flux by using the increasing number of WOCE section measurements of the ocean heat transport as constraints.

4) The ability to model the oceanic transports and storage of carbon lag behind our ability to model heat and freshwater transports. For carbon, more measurements as well as uniform standards are needed. Increased resolution in the oceanic components of coupled models is needed to study storage and sequestration. This requires additional computer power.

5) Time-dependent global ocean state estimation based on data assimilation has been performed at 2° resolution. Higher resolution estimation awaits increased computer resources.

It was clear from the workshop that much more remains to be done through collaboration between researchers. It was gratifying to see that an evening meeting to discuss future ocean hydrography measurements led to the formation of an informal group that will seek, through the WCRP's project on Climate Variability and Predictability (CLIVAR) and through JGOFS, to co-ordinate and set standards for the re-occupation of the WOCE/JGOFS sections during the coming decade. This activity was advanced further during the IGBP Open Science Conference in Amsterdam July 10-13.

The majority of funding for the workshop came from JGOFS, IOC, US WOCE, US JGOFS, NOAA, WCRP, Southampton Oceanography Centre and from the UK Global Environmental Research Committee. This support is gratefully acknowledged.

The poster abstracts and programme can still be viewed on the WOCE website www.woce.org (under NEWS). We plan to have short papers based on some of these in the next issue of the WOCE Newsletter.

Summary report of SCOR Working Group 110: Intercomparison and Validation of Ocean-Atmosphere Energy Flux Fields

*Peter K. Taylor and the Joint WCRP/SCOR Working Group on Air Sea Fluxes, SOC, Southampton, UK
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1. Introduction

During its three year lifetime, the Joint WCRP/SCOR Working Group on Air Sea Fluxes (WGASF) produced a major report (WGASF, 2000) and organised a Workshop on Air Sea Fluxes (May, 2001, near Washington DC). This note summarises the Report and the Workshop aims and conclusions.

2. Terms Of Reference

The Terms of Reference of the WGASF were: (1) To review the requirements of different scientific disciplines for surface flux data sets; (2) to catalogue available surface flux data and flux-related data sets, including those from the reanalysis projects and to review the strengths and weaknesses of these data sets; (3) to inform the scientific community of the work of the group by the use of the World Wide Web, by the publication of the final catalogue and by convening at a suitable time a scientific workshop, and (4) to keep the JSC and SCOR informed of progress in the area and present recommendations for action as necessary.

3. The Final Report

The WGASF attempted to satisfy both the in depth review expected of a SCOR WG and the more rapid time-scale needed for a WCRP WG to have a direct impact on future WCRP projects. About half the Report is a review of the requirements and methods of surface flux determination. The second half deals with the evaluation of the basic meteorological variables (sea surface temperature and salinity, air temperature and humidity, wind speed and direction, waves, cloudiness, precipitation, river inflow and sea ice) and of a number of available flux products (based on in situ or satellite data, or model reanalysis).

While the conclusions with regard to the relative merits of different flux products are less precise than was originally hoped, this was partly because, as noted in the earlier chapters of the report, there are a number of issues where our knowledge remains inadequate. These include, for example, the question of the correct transfer coefficients for the turbulent fluxes, the reconciliation of measurements and radiative transfer modelling for the radiation balance. While significant disparity continues to exist between different observational data sets, errors identified in the model fluxes will remain debatable. Thus, while the report cannot be a definitive review of air-sea flux research, the WGASF has tried to produce a reasonably balanced, authoritative assessment of the present state of air sea flux determination.

The WG conclusions are in the body of the report and summarised in the final Chapter. In addition, at the December 1999 meeting the WG adopted some specific recommendations. These were as follows (with a note on progress since the report publication):

- Recognising that present reanalyses are not perfect the WG recommended that: Reanalyses should be performed every 5-10 years by more than one centre; adequate resources should be provided for the reanalysis efforts to improve their surface fluxes, to carry out and evaluate the reanalyses and to ensure that they are easily available to the entire scientific community. Surface fields should be output every 3 hours. (ERA40, NCEP2, and the new GEOS represent the recent round of reanalysis activities).
- Evaluation of the surface fields and fluxes from global operational NWP systems will benefit future reanalyses as well as provide critical guidance and product uncertainty estimates to users of these flux products. The WGNE's plans to archive and evaluate the surface fields and fluxes from a number of global NWP systems should therefore be supported. (This is now underway as the WGNE SURFA project).
- A network of high quality "flux reference platforms" (combination of long-term moorings and ships) should be established to deliver highly accurate values of stress and all components of the air-sea heat fluxes for, *inter alia*, verification of surface fields and flux estimates from satellites and models, and the long term calibration of satellite sensors. (The establishment of "Flux Buoys" is accepted as a part of the Global Ocean Observing System and WMO has implemented the VOS-Clim project for improved ship data).
- There is a continuing need to compare and assess the quality of fluxes derived from various sources and to evaluate the parameterisations used. Encouragement should be given to efforts to enhance the reliability of momentum, net heat and freshwater fluxes by combining the best estimates from these various sources.
- Support should be provided for the continuing assembly of flux and flux-related data sets (in particular Voluntary Observing Ship-based collections such as COADS and other historical data). Continued efforts are needed to remove non-stationary observational biases in historical data. Basic meteorological variables should be included as well as uncertainties, error estimates and adequate documentation for all flux data sets. A catalogue of flux data sets should be maintained on the

Internet. (Although the WGASF began a web-based catalogue, it was not fully completed; at the WGASF Workshop there was a recommendation that it should be extended).

- Research and field experiments are needed to improve boundary layer parameterisations and bulk formulae, especially in regions where our physical understanding is poor. Adequate resources for complete analysis of the resulting data are necessary to realise the full benefits of the field experiments. (Present activities include CLIVAR regional experiments, the SOLAS programme, and the SeaFlux initiative).

4. The Workshop

The WCRP/SCOR Workshop on Intercomparison and Validation of Ocean-Atmosphere Flux Fields was held at the Bolger Center, Potomac, MD, (May 21 - 24, 2001). The aims included: Fostering collaboration between the three central areas of endeavour in this work - modelling, remote sensing and verification - and providing a forum for flux evaluations complementary to those presented in the WGASF report. Three days of the Workshop were devoted to scientific presentations grouped as: Keynote Talks, Flux Products from Modelling and Data Assimilation, Validation of Flux products, Fields from Remote Sensing, and Measurements and Parameterisations. The fourth day was spent in Breakout Groups (see below).

The recommendations of the Breakout Groups are on the WGASF web site and are summarised here. Breakout Group 1 on "Parameterisations and Measurement" suggested the need for an Airflow Distortion experiment comparing a Research Ship with suitable reference platforms; a Technical Manual on Air-Sea Measurement Methods; a Radiation Measurement Comparison experiment to compare ship-borne instrumentation with a platform that is fully instrumented to Baseline Surface Radiation Network standards; a marine Flux-Profile experiment and Coastal Ocean Case Study experiments.

Breakout Group 2 on "Verification" stressed the need to validate air-sea flux data sets by comparison to high-quality observations, in which respect it supported the planned activities of SURFA to verify the near-surface fields from numerical weather prediction (NWP) centres using high-quality observations.

Error estimates are needed for all air-sea flux data sets. These could be developed from the statistics compiled from data assimilation at NWP centres. An extensive intercomparison of all flux fields is still required. The WGASF on-line catalogue of flux fields should be expanded and include the evaluations. Indeed, there is an outstanding need to ensure the open distribution, preservation and availability of air-sea flux data sets and products. Finally, new methods of direct precipitation measurement over the ocean are still desirable.

Breakout Group 3 considered "Flux Field Improvement In The Future". There is a need: To combine flux and meteorological products from different sources including satellite data; to achieve more timely delivery; to provide detailed error estimates, particularly the space-time distribution of error covariances, and to provide all flux data sets with metadata (including a comprehensive buoy metadata catalogue). Required improvements to flux products include increased spatial and temporal resolution; parameterisations valid over a wider range of environmental conditions and better radiative flux estimates. The use of various flux fields as forcing functions for atmospheric and oceanic general circulation models would identify errors in the products and help validate the flux fields.

Support was stated for the proposed Global Precipitation Mission (GPM), reference site buoys, development and maintenance of *in situ* data archives accompanied by the collocated satellite data (e.g. SEAFLUX), and efforts to improve and qualify VOS observations (e.g. the VOS-Clim project). Also to be supported were: Regional flux field synthesis and validation, analysis of large-scale heat and fresh water imbalances, validation and improvement of the wind stress fields and improvement of the long-term space-time series of global sea-air flux anomalies.

References

WGASF (2000) Intercomparison and Validation of Ocean-Atmosphere Energy Flux Fields - Final report of the Joint WCRP/SCOR Working Group on Air-Sea Fluxes (P. K. Taylor, ed.) November 2000, WCRP-112 (WMO/TD-No. 1036), 306 pp

(for availability see the WGASF web site:

<http://www.soc.soton.ac.uk/JRD/MET/WGASF/>)

Lynne Talley receives Rosenstiel Award:

Congratulations to Dr Lynne Talley of Scripps Institution of Oceanography for gaining the "Rosenstiel Award for Excellence in Physical Oceanography". The award is given by the Rosenstiel School of Marine and Atmospheric Science at the University of Miami.

Lynne has played a leading role in WOCE. She is currently a member of the WOCE SSG and is PI for the Pacific and Indian WOCE atlases.

Small error reported and corrected in SIO/ODF WOCE Hydrographic Program Data

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The Scripps Institution of Oceanography's Oceanographic Data facility (ODF) has discovered and corrected a small error in reported Mark III CTD temperature data for most ODF cruises that took place during 1992-1999. A complete list of affected data sets appears below.

Description of the problem:

ODF calibration laboratory CTD temperatures are recorded on the ITS90 temperature scale, but ODF internally uses the IPTS68 scale in CTD data processing. The error involved one term in the conversion of the ITS90 CTD calibrations to IPTS68.

Description of the error:

The size of the error is essentially linear with temperature: Approximately $-0.00024^{\circ}\text{C}/^{\circ}\text{C}$, with -0.00036°C offset at 0°C . In other words, previously reported ODF processed final CTD temperature data are low by 0.00756°C at 30°C , with

the error decreasing to being low by 0.00036°C at 0°C . The error is the same in sign and almost exactly the same magnitude whether the final processed CTD temperatures were reported as IPTS68 or as ITS90.

Description of the repair:

All ODF CTD temperatures for the affected cruises have been replaced CTD conductivities have been recalculated and replaced to account for the temperature change, but reported CTD salinity and oxygen data are not significantly affected. Revised final data sets have been prepared and will be available soon from ODF (<ftp://odf.ucsd.edu/pub/HydroData>). The data will eventually be updated on the whpo.ucsd.edu website as well.

The Oceanographic Data Facility staff, and I as scientific advisor, deeply regret this error. Fortunately the size of the temperature error is quite small relative to typical variability in ocean waters of various temperatures.

Data sets affected

WOCE section name	P.I.	Cruise dates
SO4P	Koshlyakov/Rickman	Feb.-Apr. 1992
P14C	Roemmich	Sep. 1992
PCM11	Rudnick	Sept. 1992
P16A/P17A	Reid	Oct.-Nov. 1992
P17E/P19S	Swift	Dec. 1992 - Jan. 1993
P19C	Talley	Fef.-Apr. 1993
P17N	Musgrave	May-June 1993
P14N	Roden	July-Aug. 1993
P31	Roemmich	Jan.-Feb. 1994
A15/AR15	Smethie	Apr.-May 1994
109N	Gordon	Jan.-Mar. 1995
108N/105E	Talley	Mar.-Apr. 1995
103	Nowlin	Apr.-June 1995
104/105W/107C	Toole	June-July 1995
107N	Olson	July-Aug. 1995
110	Bray/Sprintall	Nov. 1995
Non-WOCE cruise		
Antarktis X/5	Peterson	Aug.-Sept. 1992
Artic Ocean 94	Swift	July-Sept. 1994

Data sets affected but not yet corrected

SO41	Whitworth	May-July 1996
ICM3	Whitworth	Jan.-Feb. 1997
Arctic Ocean 97	Swift	Sept.-Oct.1997
HNRO7	Talley	June-July 1999
KH36	Talley	July-Sept. 1999

Data sets not affected

All final processed CTD data from ODF cruise dates prior to 1992.

All final or preliminary data from ODF cruise not using NBIS CTDs.

Artic Ocean	Swift	July-Sept. 1996
A24	Talley	May-July 1997
XP99	Talley	Aug.-Sept. 1999
KH38	Talley	Feb.-Mar. 2000
XP00	Talley	June-July 2000

A Scientific Celebration of WOCE

Piers Chapman, US Woce Office, Texas A & M University, USA. chapman@tamu.edu

All good things come to an end sooner or later, and for WOCE the end is drawing nigh! November 2002 will see the final WOCE meeting, an international gathering to be held in San Antonio, Texas that will celebrate and assess the programme's achievements and look to the future. The meeting is to be held at the Henry B. Gonzales Convention Center in downtown San Antonio. We have reserved the main ballroom, which offers 40,000 square feet of space. The building is adjacent to the San Antonio Riverwalk, the centre of the city's nightlife.

Co-chairs of the meeting are Worth Nowlin and Carl Wunsch, both of whom have been involved with the programme since its inception. They have put together an international science team (see box) to plan the programme for the meeting. Logistics will be handled by the U.S. WOCE Office with assistance from the WOCE IPO in Southampton, and funding support is being lined up from national and international sponsors.

Although the official title of the meeting is "Achievements of the World Ocean Circulation Experiment," the short title "WOCE and Beyond" more succinctly describes what is being planned to demonstrate progress towards WOCE's goals. A main theme is an exploration of the new "quantitative oceanography" that WOCE has helped make possible. By this, we mean both that observations are quantifiable and include statements of uncertainty, and that theories are testable. As a very simple example, when one describes the current flowing through a passage, one should discuss the flow in terms of both velocity and variability rather than merely giving a direction. A larger-scale example could be the use of altimetry, sea surface temperature and ADCP data to show changes in western boundary current pathways.

We plan a five-day meeting (Monday-Friday), consisting of plenary talks each morning, with the Monday-Thursday afternoons given over to poster presentations and discussion groups. We aim to have all the posters available for this whole period, divided into themes, and each theme will be introduced during a plenary session.

Themes for the plenaries are presently being discussed and will be displayed initially on the Conference web site. <http://www.WOCE2002.tamu.edu>.

This article is merely an initial invitation to mark your calendar for 18-22 November, 2002. We shall be sending out more detailed information on the programme, how to register, and other matters later in the year. Links will also be available through the WOCE IPO and U.S. WOCE Office web sites.

WOCE 2002 Scientific Committee

Worth Nowlin (Texas A&M University, USA;
co-chair)

Carl Wunsch (Massachusetts Institute of
Technology, USA; co-chair)

Eric Chassignet (University of Miami, USA)

John Church (CSIRO, Hobart, Australia)

Howard Freeland (DFO, Sydney, Canada)

Kimio Hanawa (Tohoku University, Japan)

Greg Johnson (NOAA/PMEL, USA)

Jochem Marotzke (Southampton University, UK)

Monika Rhein (University of Bremen, Germany)

Anne-Marie Treguier (IFREMER, Brest, France)

Doug Wallace (University of Kiel, Germany)

Corrections: International WOCE Newsletter No. 40

1. In Figure 3, page 21, of the article "Interannual variability of natural and anthropogenic carbon and transient tracers in the Labrador Sea, 1993-2000" by Kumiko Azetsu-Scott *et al.*, the units that are marked "mol/kg" should be "mmol/kg". The Y axis label on the CT plot should also read CT rather than CTant. Furthermore, we must apologise for the poor reproduction of this figure. A corrected version is available from the web (www.woce.org/publications/newsletters/news40/contents.html)

2. In Figure 2, page 15, of the article "Subinertial variability of transport estimates across "48°N" in the North Atlantic" by Katja Lorbacher and Klaus-Peter Koltermann the scale of Heat Transport should be PW, not Sv.

Interested in North Atlantic Ocean Variability?

Then you will be interested in the ICES Annual Ocean Climate Status Summary

The IAOCSS condenses information from 12 time series in the North Atlantic subpolar gyre, the Nordic Seas, and the North Sea into a single report. Hydrographic data from **1900** to **2001** are presented. The report also summarises the state of the atmospheric variability as represented by the North Atlantic Oscillation Index, and this year's issue includes a discussion of other influences on oceanic variability.

The online version of the IAOCSS contains links to the **data** behind each time series, to the huge **ICES database**, and to other data resources of interest.

IAOCSS 2000/2001 is now available at
www.ices.dk/status/clim0001/

MEETING TIMETABLE 2001

Sep 17-20	CLIVAR/JSC Working Group on Coupled Modeling (WGCM)	Bracknell, UK
Oct 21-28	IAPSO/IABO 2001: An Ocean Odysey	Mar del Plata, Argentina
Nov 13-14	IMS Meeting Statistical Approaches to the Ocean Circulation Inverse Problem	Tallahassee, USA
*Dec 6-7	WOCE SSG-28	Scripps IO., La Jolla, USA
Dec 10-14	AGU 2001 Fall Meeting	San Francisco, USA

2002

Feb 11-15	AGU 2002 Ocean Sciences	Honolulu, USA
Mar 27-29	Tracers in Physical Oceanography	Univ. Washington, Seattle, USA
Apr 22-26	EGS XXVII General Assembly	Nice, France
May (?)	Working Group on Ocean Model Development	Hamburg, Germany
May 28 - June 1	AGU 2002 Spring Meeting	Washington DC, USA
*Nov 18-22	WOCE FINAL CONFERENCE (www.WOCE2002.tamu.edu)	San Antonio, Texas, USA

*Denotes International WOCE Meeting

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CONTENTS OF THIS ISSUE

❑ News from the WOCE IPO	<i>W. John Gould</i>	1
❑ Contributions		
Countdown to the Final Issue of the WOCE Global Data	<i>N. Penny Holliday</i>	3
The Current Meter Data Assembly Centre	<i>James Crease</i>	5
The WOCE Atlas Series	<i>Piers Chapman</i>	6
The WOCE Website and Bibliography	<i>Peter M. Saunders</i>	8
WOCE/JGOFS Workshop on the Ocean Property Transports	<i>W. John Gould, et al.</i>	10
Intercomparison and Validation of Ocean-Atmosphere Energy Flux Fields. WCRP/SCOR WG 110 summary report	<i>Peter K. Taylor</i>	11
A Scientific Celebration of WOCE	<i>Piers Chapman</i>	14
❑ Miscellaneous		
WOCE Hydrographic Program Data (Error)	<i>James Swift</i>	13
Meeting Timetable (2001/2)		15